BBC RD 1974/22

Engineering Research Report

The work covered by this report was undertaken by the BBC Research Department for the BBC and the IBA

UHF RELAY STATIONS: log-periodic transmitting aerial for Ogmore Vale

G.H. Millard, B.Sc., M.Inst.P.

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION May 1974

BBC RD 1974/22
UDC 621.396.721
621.396.677

UHF RELAY STATIONS: LOG-PERIODIC TRANSMITTING AERIAL FOR OGMORE VALE

G.H. Millard, B.Sc., M.Inst.P.

Summary

The report describes an experimental low-power vertically-polarised transmitting aerial which comprises a stack of four log-periodic aerials. Factors affecting the utility of this aerial compared with other types are discussed.

Issued under the authority of

P. Rainger

Head of Research Department

Research Department, Engineering Division,
BRITISH BROADCASTING CORPORATION

May 1974

(RA-131)

UHF RELAY STATIONS: LOG-PERIODIC TRANSMITTING AERIAL FOR OGMORE VALE

Section	Title	Page
	Summary	Title Page
1.	Introduction	1
2.	General arrangement	1
3.	Radiation patterns	1
4.	Admittance	6
5.	Gain	6
6.	Power rating	6
7.	Wind and ice loading	8
8.	Transport	8
9.	Conclusions	9
10.	References	9

UHF RELAY STATIONS: LOG-PERIODIC TRANSMITTING AERIAL FOR OGMORE VALE

G.H. Millard, B.Sc., M.Inst.P.

1. Introduction

Most u.h.f. relay stations built by the BBC transmit from either standard cardioid aerials[1] or arrangements of panel aerials;[2] those built by the IBA are similar. It has been suggested that simple arrangements of log-periodic aerials may result in economies when used instead of panel aerials at low-power stations. The aerial described was built by the BBC Research Department for station 106·30 Ogmore Vale in order to gain experience in the use of the log-periodic aerial for transmission, particularly in respect of its immunity to weather conditions. Attention is given to aspects which might give trouble in general production and, where appropriate, comparison is made with the equivalent panel aerial.

The Ogmore Vale aerial is required to operate on Channels 53 (P-4), 57 (BBC-Wales), 60 (IBA) and 63 (BBC-2).

2. General arrangement

The transmitting aerial originally proposed for Ogmore Vale was a single 4 wavelength RBL 'Trough' aerial, a type designed for rebroadcast reception. At a later date the proposal was changed to two tiers each of one panel aerial. When the final change to log-periodic aerials was made, it was decided to use four tiers, this arrangement giving slightly more gain than the panel arrangement.

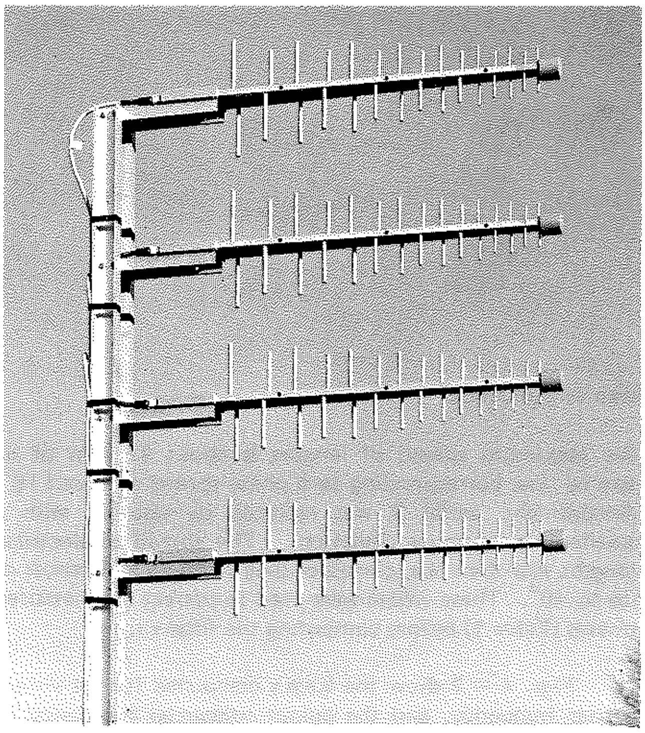


Fig. 1 - The aerial mounted on a simulated pole

The aerials are supported by friction clamps on a 168 mm diameter steel pole with an inter-tier spacing of 457 mm. Fig. 1 is a photograph of the aerial array mounted on a simulated pole. Each log-periodic aerial is the standard ruggedised form with a polythene insert between the booms;[3] the form of end clamp has however been modified to suit this particular application. Each tier is connected by a length of approximately 3 m of coaxial cable type BICC T 3364 to a four-way splitter transformer manufactured by E.M.I. Electronics Ltd. (see Fig. 2).

The whole assembly is mounted as a top-mast on a 45 m tower, giving a mean aerial height of 46·2 m.

3. Radiation patterns

The vertical radiation pattern (v.r.p.) of the aerial is required to be gapfilled. The method adopted is by means of a phase perturbation added to the phase progression required to give the specified beam tilt of 2°. The spacing between adjacent tiers is 457 mm so that the path difference between the feeds to adjacent tiers required to give a beam tilt of 2° is

$$457 \sin 2^\circ = 16 \text{ mm air line}$$

$$\text{or } 10{\cdot}6 \text{ mm polythene line.}$$

This corresponds to a phase progression of about 15° per tier at mid-band.

The gapfilling distribution chosen was

Tier 1 (top)	0°
Tier 2	60°
Tier 3	20°
Tier 4	10°

These phases were converted to cable lengths at the mid-band frequency and combined with those required for beam tilt. Lengths of distribution feeder type T3364, each nominally 3·1 m long, were carefully measured and cut to give the required differences. The electrical lengths were checked by means of a vector voltmeter. The differences from the design values were less than ±5° on all channels and this accuracy was judged to be sufficient.

When the aerial was assembled, current amplitudes and phases were measured at the inputs to each aerial and the vertical radiation pattern was calculated from these values. Table 1 gives the measured input currents for the vision carrier and colour subcarrier frequency of each channel.

Direct measurements of the v.r.p. were also made, the aerial being mounted on its side and rotated on a turntable. Initially there was some disparity between the measured

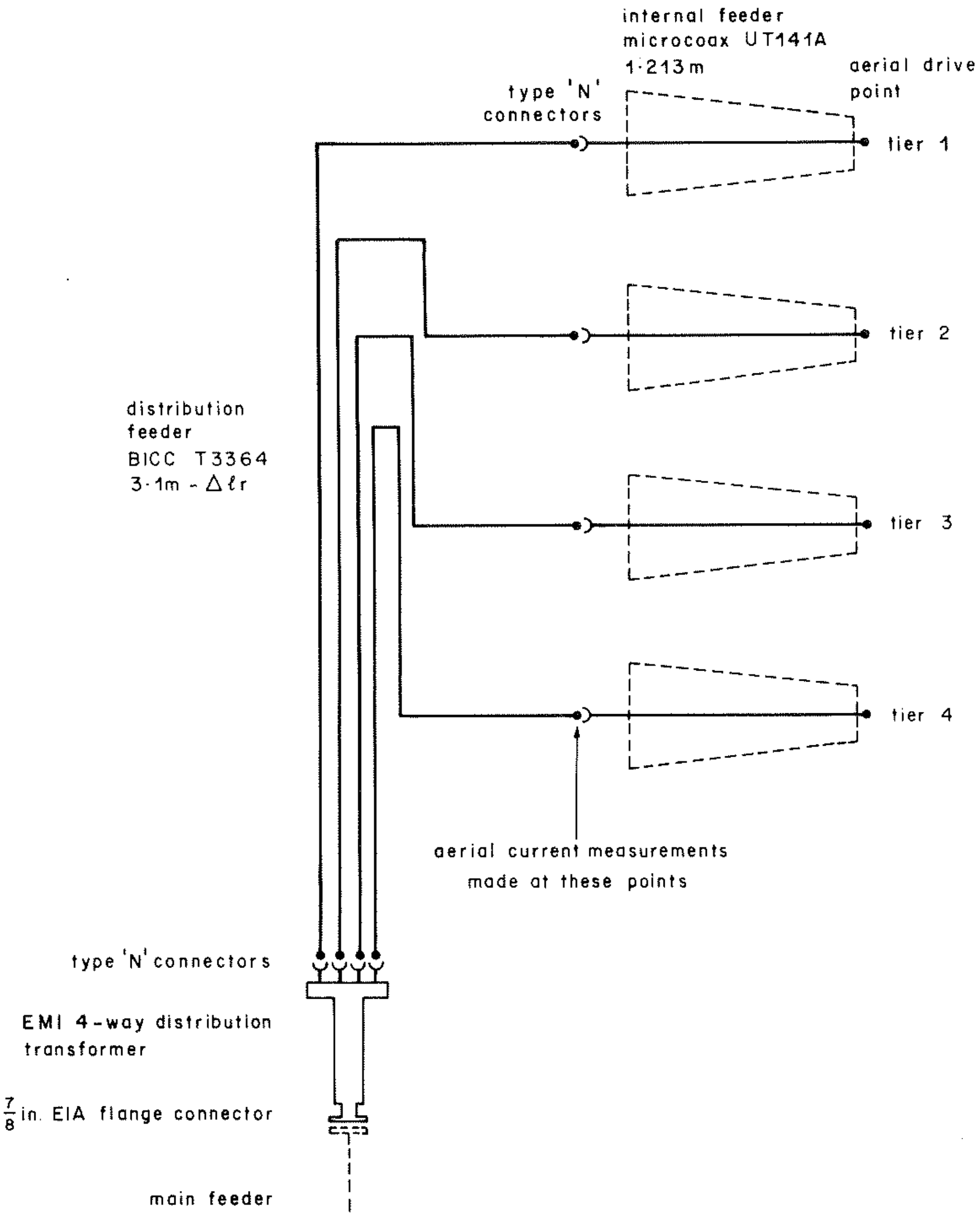


Fig. 2 - Arrangement of distribution feeder

and calculated v.r.p.s, the second minimum being significantly deeper on the direct measurement. The cause was traced to apparent differences in the electrical lengths of the internal 'MicroCoax' feeders in each aerial even though nominally equal physical lengths had been used. A time-domain reflectometer was used to examine the relative locations of the feed-point discontinuity on each aerial; Fig. 3 shows a specimen measurement. It may be seen that the feed to aerial 3 appears shorter than the rest* and that the maximum spread of lengths is about 17 mm of air spaced line, corresponding to a phase spread of about 15°. Accordingly, aerial 3 was replaced by another with a smaller and opposite deviation. The spread of electrical lengths was then less, corresponding to phase differences of up to ±6°. These values were used to correct the measured phases (Table 1) before computing the final v.r.p.s.

Figs. 4 – 7 show the v.r.p.s computed for the vision-carrier frequency, and the colour subcarrier frequency of each channel. Taking the service area to lie in the range 0° to 25° below the horizontal, the in-channel variations do

---

* A subsequent examination showed that the cable had been shortened during assembly.

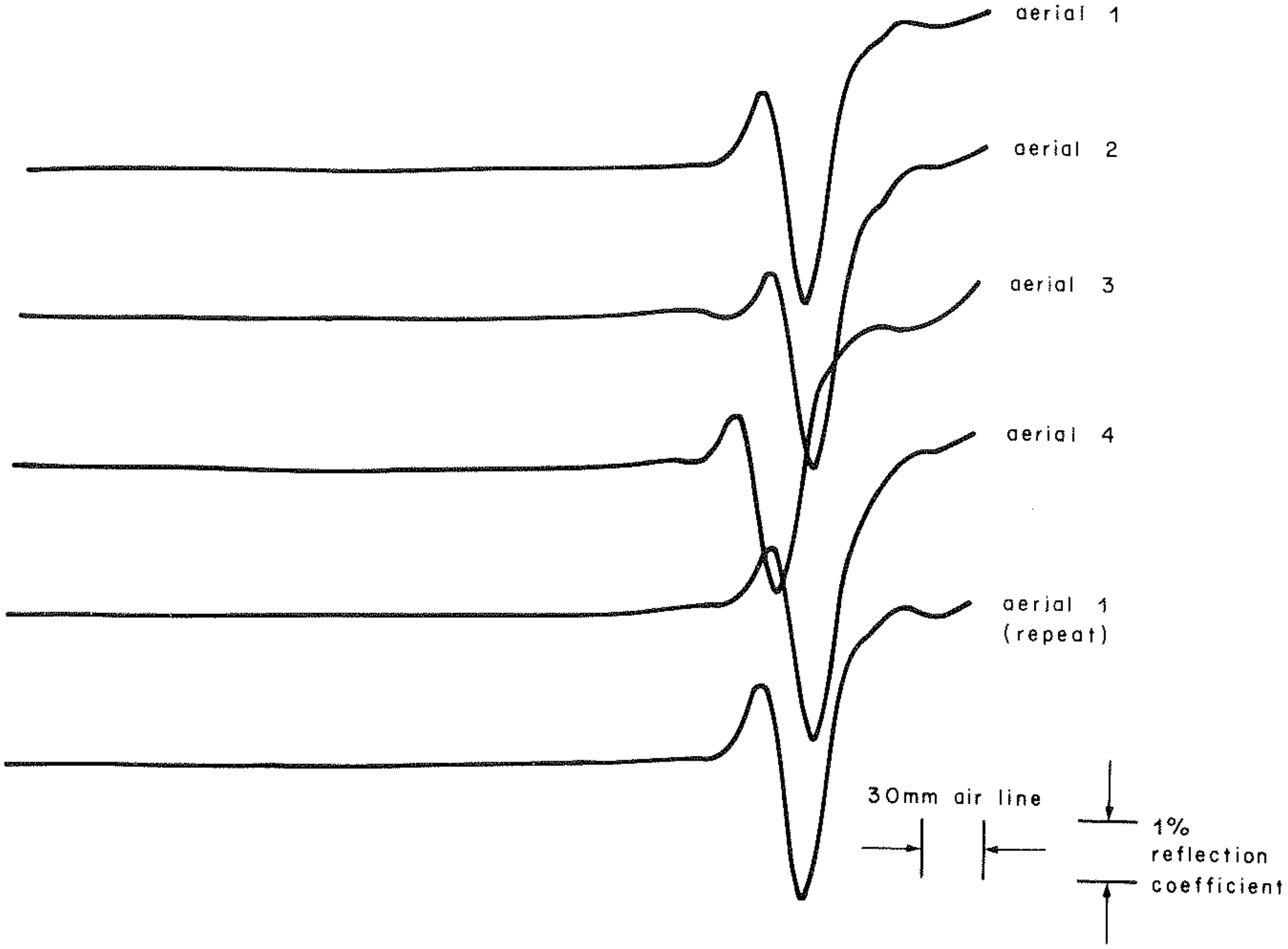


Fig. 3 - Comparison of the electrical lengths of the internal feeders

not exceed 2 dB and the variations between channels do not exceed 3 dB. These variations are less than the normal specified limits of 3 dB and 6 dB respectively. Figs. 4 – 7 also show the normal specification for the minimum relative field as a function of the angle of depression. The specification does not extend to angles beyond 25°. It will be seen that the requirement is met on all four channels.

Figs. 8 – 11 compare the mean of two measured v.r.p.s with those computed from current measurements. In general the agreement is good, particularly over those angles giving the service. The most significant disparities are one of 2 dB at 17° on Channel 63 and one of 4 dB at 26° on Channel 57. The calculated patterns are taken as more representative because the assessment of in-channel variations is likely to be more precise. The conclusion is that current measurements at the inputs to each aerial will give a sufficiently accurate indication of the v.r.p.

The horizontal radiation pattern (h.r.p.) of the aerial is shown in Fig. 12. This pattern is substantially independent of frequency.

In assessing the service cover it is desirable to have a ready means of determining the effective radiated power (e.r.p.) at any combination of azithmuthal and vertical angle. This facility is given by Fig. 13.

TABLE 1

Current Ratios and Phases

		1	2	3	4
Channel 53	Vision (dB)	+0·25	+0·3	+0·35	0
	ϕ°	+37·5	+78	+34·5	0
	Colour (dB)	+0·3	+0·2	+0·3	0
	ϕ°	+38	+86	+35	0
Channel 57	Vision (dB)	+0·35	+0·35	+0·4	0
	ϕ°	+36·5	+77·5	+30·5	0
	Colour (dB)	+0·4	+0·35	+0·45	0
	ϕ°	+37	+86	+34	0
Channel 60	Vision (dB)	−0·2	−0·15	+0·2	0
	ϕ°	+39·5	+82	+37·5	0
	Colour (dB)	+0·2	+0·25	+0·2	0
	ϕ°	+41	+88	+38	0
Channel 63	Vision (dB)	+0·4	+0·3	+0·15	0
	ϕ°	+39	+89·5	+41·5	0
	Colour (dB)	+0·45	+0·3	+0·4	0
	ϕ°	+40·5	+87·5	+41·5	0

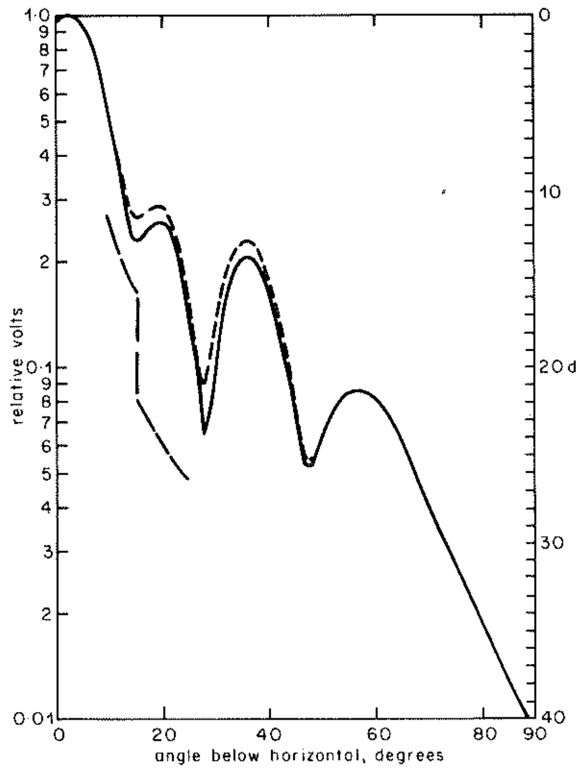


Fig. 4 - Vertical radiation pattern: Channel 53

———— Vision carrier - - - - - - colour subcarrier

— — — minimum field specification

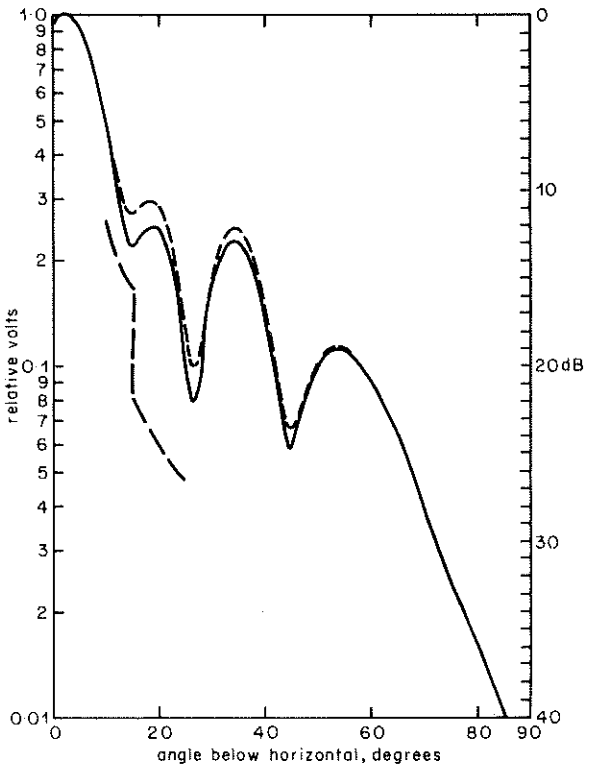


Fig. 5 - Vertical radiation pattern: Channel 57

———— vision carrier - - - - - - colour subcarrier

— — — minimum field specification

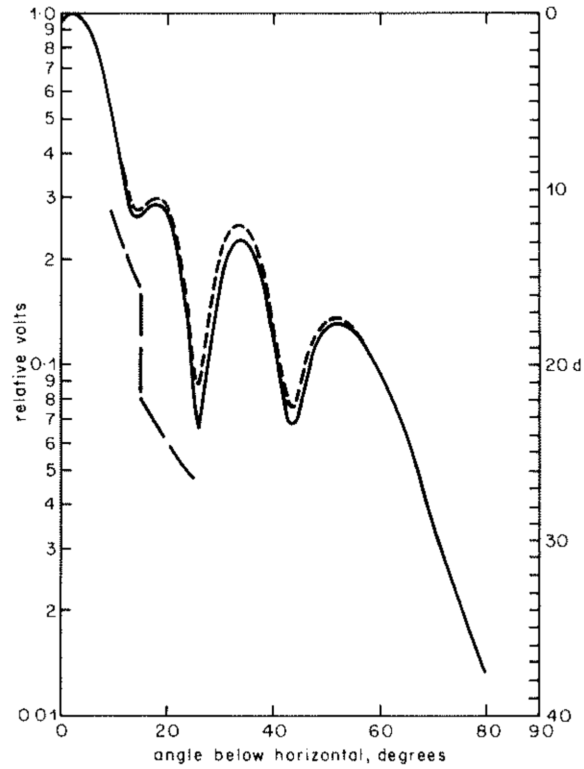


Fig. 6 - Vertical radiation pattern: Channel 60

———— vision carrier - - - - - - colour subcarrier

— — — minimum field specification

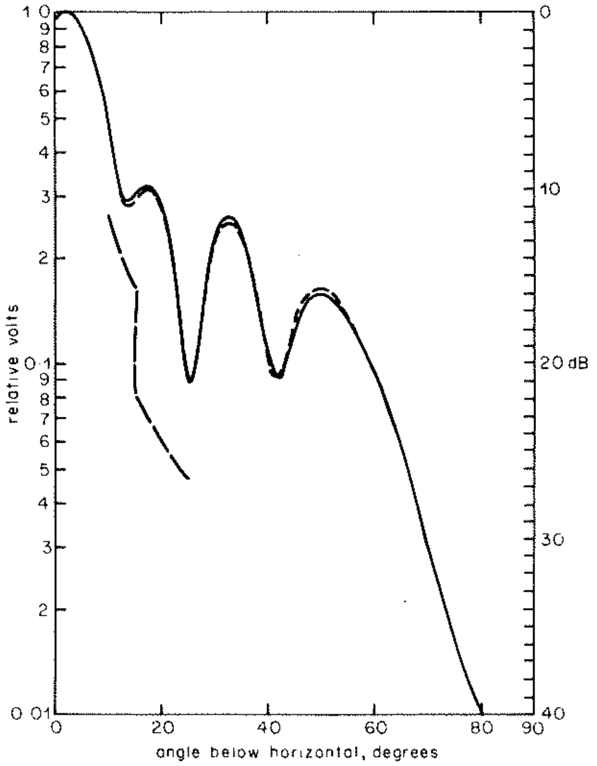


Fig. 7 - Vertical radiation pattern: Channel 63

———— vision carrier - - - - - - colour subcarrier

— — — minimum field specification

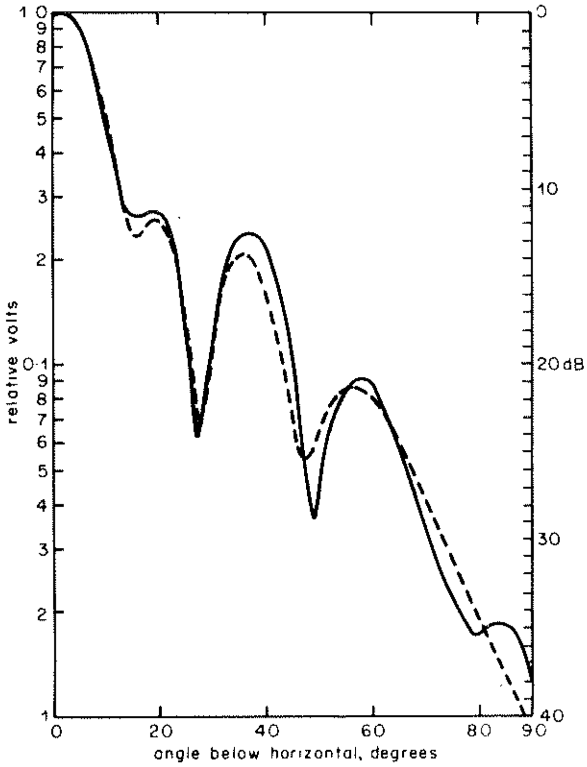


Fig. 8 - Comparison of measured and calculated v.r.p.s: Channel 53

——————— direct measurement
– – – – – – – calculated from current measurements

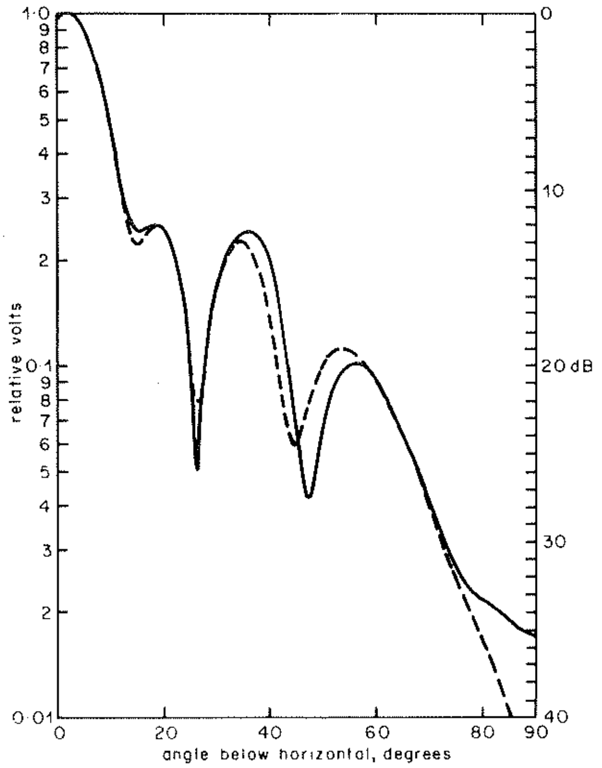


Fig. 9 - Comparison of measured and calculated v.r.p.s: Channel 57

——————— direct measurement
– – – – – – – calculated from current measurements

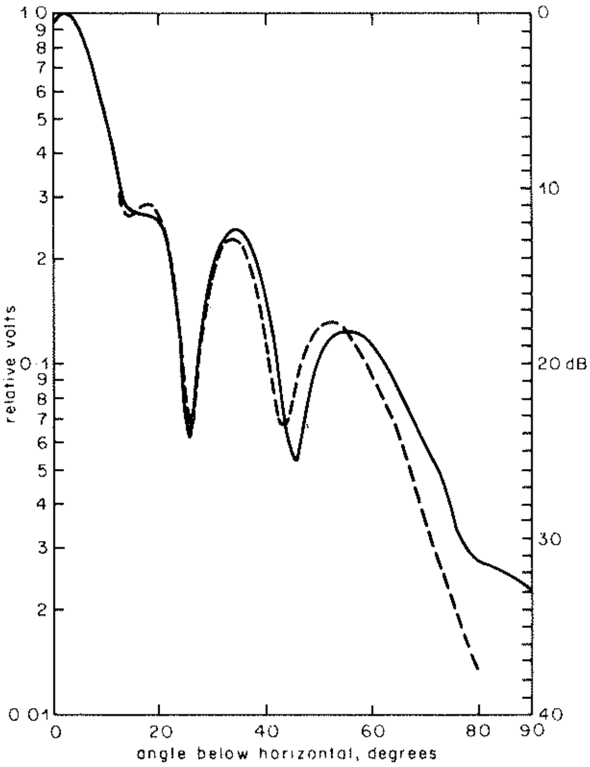


Fig. 10 - Comparison of measured and calculated v.r.p.s: Channel 60

——————— direct measurement
– – – – – – – calculated from current measurements

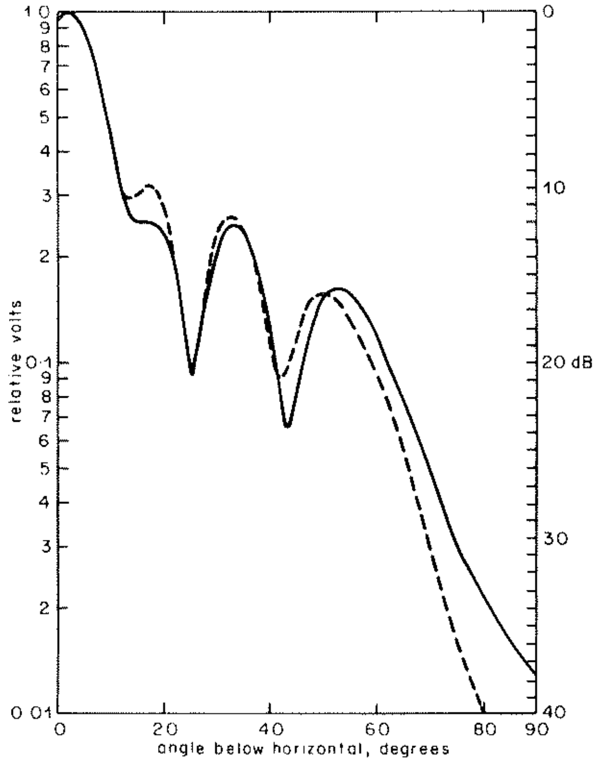


Fig. 11 - Comparison of measured and calculated v.r.p.s: Channel 63

——————— direct measurement
– – – – – – – calculated from current measurements

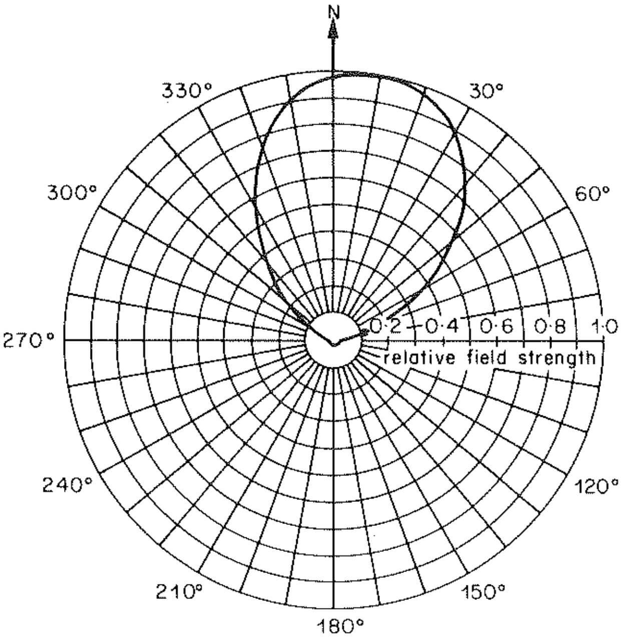


Fig. 12 - Horizontal radiation pattern

4. Admittance

The maximum reflection coefficient of a single log-periodic aerial is normally 11% but may worsen by 1 – 2% in heavy rain.[3] Allowing for impedance variations in the distribution feeder and a small mismatch at the distribution transformer, it seems possible that the reflection coefficient of an array of four log-periodic aerials could reach 15% at some frequencies compared with 10% for the panel aerial.[2] This higher reflection coefficient can be accepted for a typical low-power installation as the reflection loss at the transposer is not likely to be less than 12 dB. In the particular case of the Ogmore Vale aerial the requirements for beam tilt and gapfilling help to reduce the overall reflection coefficient. Fig. 14 shows the measured admittance characteristic over each of the four operating channels, referred to the terminals of the distribution transformer. It may be seen that on no channel is the reflection coefficient greater than 7%.

After assembly the aerial was left out-of-doors for several days during which there was heavy rain. The reflection coefficient of each aerial was remeasured and one was found to be degraded. The cause was traced to penetration of water between the booms and the polythene wedge; the water then reached the drive-point by capillary action. Accordingly, the drive-point encapsulation of all the aerials was remade. Grooves were cut in the polythene wedge to act as capillary traps and the whole region around the drive point was liberally smeared with silicone grease before potting. Each aerial was checked for water penetration by total immersion of the drive point encapsulation. The present technique appears to give a satisfactory seal.

5. Gain

The gain in the vertical plane for each channel was obtained by integration of the v.r.p. during the computation of the latter. The maximum/mean ratio of the h.r.p. was added to these figures to give the maximum intrinsic gain. In this way, the loss resulting from v.r.p. gapfilling is automatically taken into account. The results are shown in Table 2. The calculation of losses in the aerial and distribution feeder is given in Table 3.

TABLE 2

Maximum Intrinsic Aerial Gain

	Stacking gain dB	h.r.p. max/ mean ratio, dB	Aerial losses dB	Net aerial gain dB
Ch. 53v	+6·81	+7·12	–0·98	12·95
53c	+6·65	+7·12	–0·98	12·79
Ch. 57v	+6·91	+7·07	–1·00	12·98
57c	+6·70	+7·07	–1·00	12·77
Ch. 60v	+6·87	+7·02	–1·02	12·87
60c	+6·77	+7·02	–1·02	12·77
Ch. 63v	+6·71	+6·97	–1·03	12·65
63c	+6·79	+6·97	–1·03	12·73

TABLE 3

Calculation of Aerial Losses

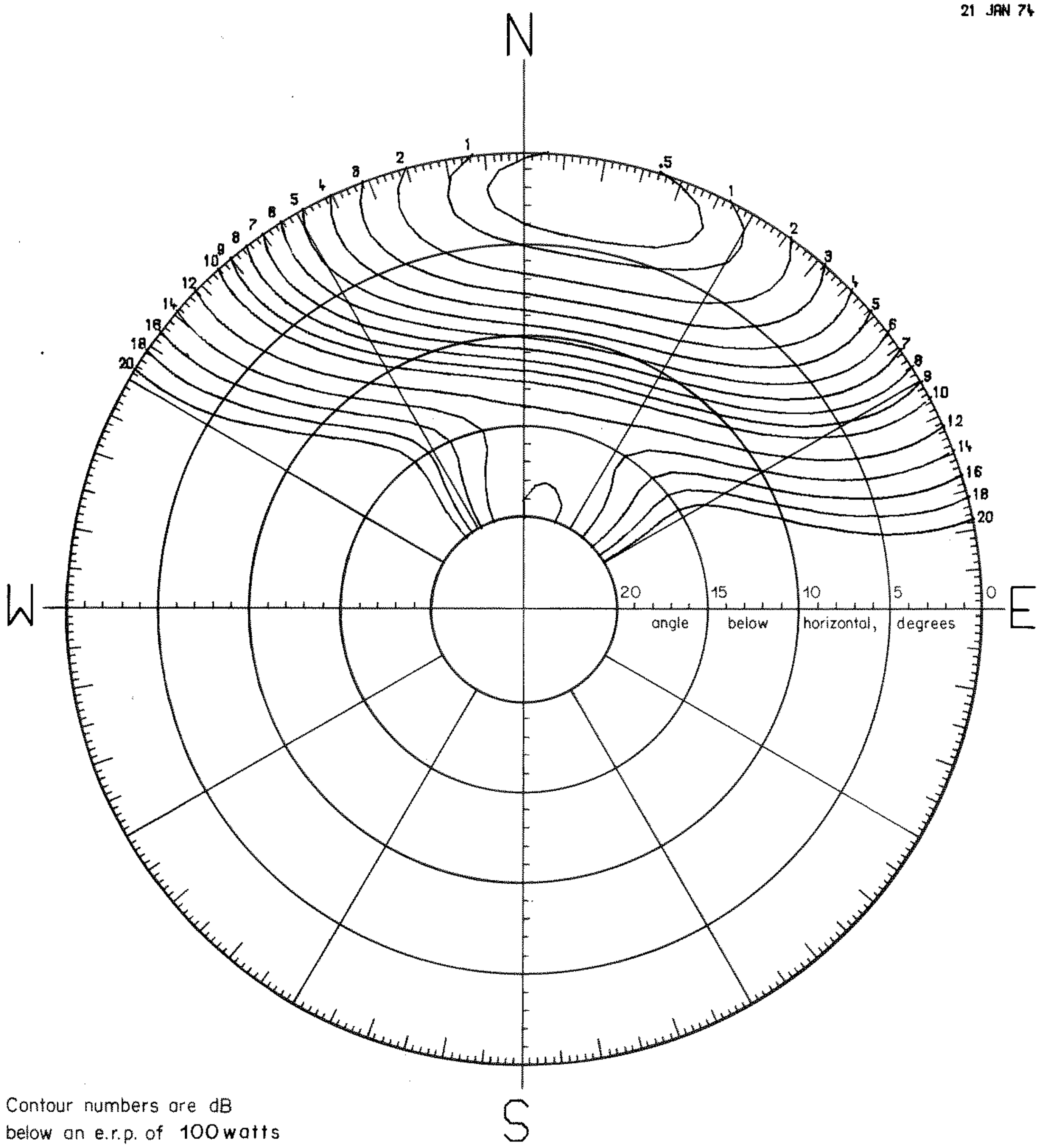
Channel	53	57	60	63
loss in 3·1m T3364, dB	0·52	0·53	0·54	0·55
loss in transformer, dB	0·10	0·10	0·10	0·10
loss in 1·21m MicroCoax UT-141-A, dB	0·36	0·37	0·38	0·38
Total aerial losses	0·98	1·00	1·02	1·03

Assuming that the main feeder and network losses at Ogmore Vale total about 3 dB, a transposer power of 10 W will give a maximum e.r.p. of about 100 W. This will meet the service requirement. The corresponding arrangement of two tiers of panels would give a maximum e.r.p. of 80 W.

6. Power rating

The power rating of the whole aerial is determined by the rating of the T 3364 distribution feeders rather than the smaller, PTFE insulated, UT 141A. This cable is rated at 350 watts at 800 MHz for an ambient temperature of 40°C

21 JAN 74



Contour numbers are dB
below an e.r.p. of 100 watts

106.30 OGMORE VALE 4 TIERS LOG-PERIODICS GAPFILLED CHANNEL 53 AE 1457

Fig. 13 - Radiation pattern plot

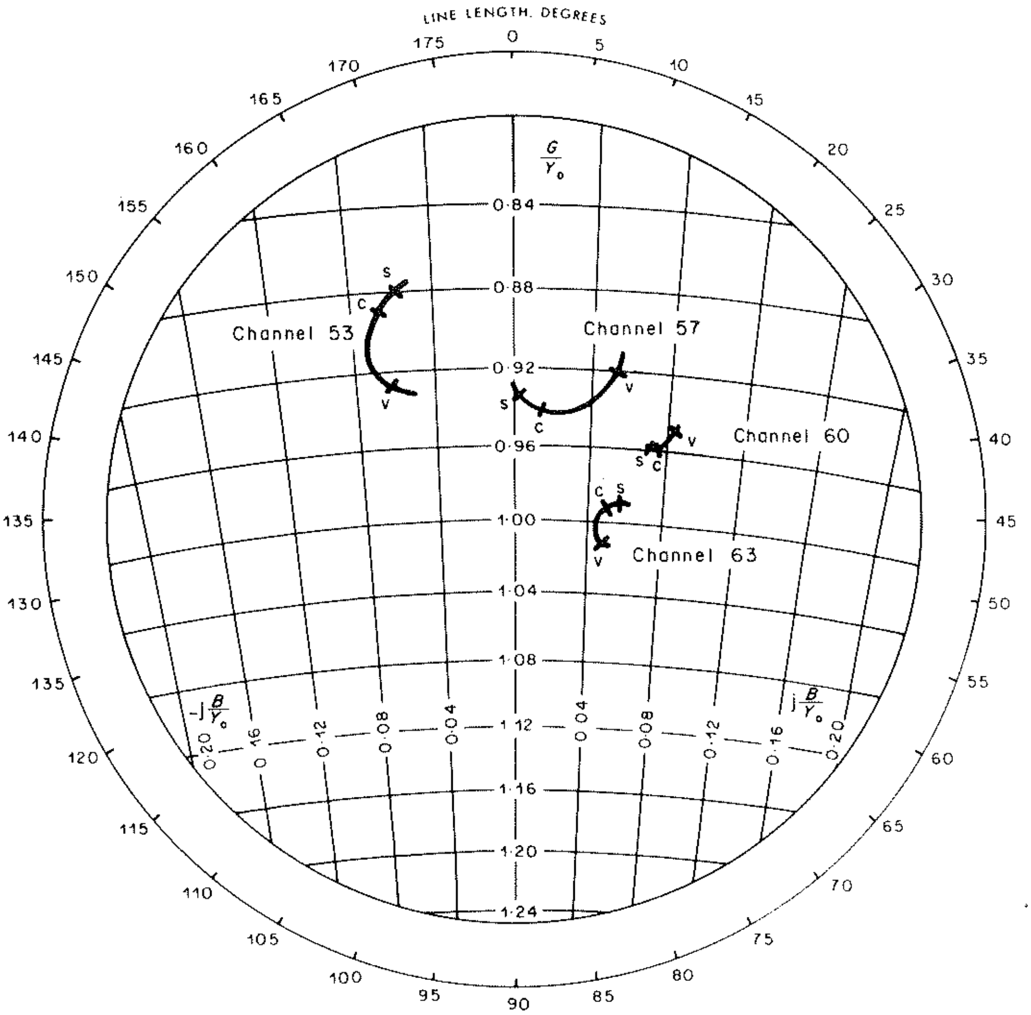


Fig. 14 - Admittance characteristics

and the type 'N' connectors have about the same limit. The power rating of the whole aerial is therefore 1·4 kW mean power or 1·7 kW peak vision power. The total power to be used at Ogmore Vale (four channels) is 40 W peak vision less the attenuation of the main feeder and the combining networks. There is, therefore, a large factor of safety.

7. Wind and ice loading

The wind loading of the array was assessed in terms of the BBC specification current at the time (January 1974) whereby every part of the aerial is assumed to be covered with ice to a radial thickness of 12·7 mm and apertures of less than 76 mm are assumed to be filled with ice. On this basis, the effective wind-loaded area of the whole aerial and mounting pole (neglecting ladder and feeders) was found to be 0·99 m^2 and the corresponding shear force was 1,665 N (375 lbs). This is approximately the same as the wind load for the equivalent printed panel aerial assessed on the same basis.

In March 1974 the basis for assessment of wind and ice loading used by the BBC was changed to follow the Code of Practice published by the British Standards Institution.[4] The design wind speed is derived from a base wind speed appropriate to the location in the United Kingdom, modified by factors which take into account local topography, surface features, height above ground level and the required probability of failure. The Code of Practice gives only general recommendations for the assessment of ice loading. Thicknesses of ice (to windward) of 15 mm and 25 mm are suggested design criteria but with wind speeds of one half or less of those occurring without ice. Since the dynamic pressure of the wind varies as the square of its speed, the increased wind-loaded area caused by ice may be more than offset by the lower speed. It appears, therefore, that log-periodic aerials will have a wind loading advantage over panel aerials but more experience in the application of the Code of Practice is needed in order to quantify the benefits.

8. Transport

Experience has shown that log-periodic aerials are sometimes damaged when being transported. Since the radiating elements are exposed, they are occasionally bent or broken through mishandling. To obviate this, each log-periodic aerial was shipped to site in a shaped wood and hardboard case. Padding was provided in the case to give added protection to the drive point encapsulation.

9. Conclusions

A simple transmitting aerial has been produced for Ogmore Vale which meets all the normal specifications. The construction and setting-to-work of the aerial has given experience in the production of log-periodic transmitting aerials which is relevant to any decision to make more extensive use of this type of aerial. The principal points to emerge are as follows:

(i) Great care in the design and fabrication of the individual aerials is required to ensure that the performance is not degraded by the adventitious penetration of water. Any variation in design proposed by a contractor should be thoroughly tested before acceptance.

(ii) Strict control of the internal feeder length is required, with possibly an electrical check after assembly.

(iii) Valid current measurements may be made at the aerial input so that the lack of a special probe facility is not important.

(iv) The slightly poorer match of the log-periodic aerial compared with the panel aerial was unimportant for Ogmore Vale and is likely to be unimportant for most stations.

(v) Simple arrangements of log-periodic aerials appear to have less wind loading than the comparable panel arrangement.

(vi) Some simple protection against mishandling is desirable.

Valuable experience of the performance of the Ogmore Vale aerial, particularly in respect of immunity to weather, may be gained if arrangements can be made to check the aerial rather more frequently than usual.

The remaining factor needed for a decision on the viability of log-periodic aerial arrays is that of cost relative to other types of aerials and the elucidation of this is being undertaken by the BBC Transmitter Capital Projects Department.

10. References

1. MILLARD, G.H. 1966. A vertically-polarized transmitting aerial for u.h.f. relay stations. BBC Research Department Report No. E-122, Serial No. 1966/74.

2. MILLARD, G.H. 1970. U.H.F. relay stations: vertically-polarized printed panel aerial. BBC Research Department Report No. 1970/17.

3. RILEY, J.L. 1973. A u.h.f. ruggedised log-periodic aerial. BBC Research Department Report No. 1973/24.

4. British Standards Institution. Code of Practice CP3: Chapter V: Part 2, September 1972.

SMW/AMM

Printed by BBC Research Department, Kingswood Warren, Tadworth, Surrey